3-7

Biofortification as a Vitamin A Deficiency Intervention in Kenya

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Executive Summary

Vitamin A deficiency is a serious global nutritional problem that particularly affects preschool-age children. Current efforts to combat micronutrient malnutrition in the developing world focus on providing vitamin and mineral supplements for pregnant women and young children and on fortifying foods through postharvest processing. In regions with a high prevalence of poverty, inadequate infrastructure, and poorly developed markets for food processing and delivery, however, these methods have had negligible impact, and biofortification has been proposed as a more effective intervention.

Inadequate dietary intake is the main cause of micronutrient malnutrition in Kenya. It is directly correlated with poverty. Micronutrient malnutrition is directly linked to 23,500 child deaths in Kenya annually. Seventy percent of children under age six have subclinical vitamin A deficiency. The situation is aggravated by a high prevalence of diseases and conditions that directly interact with a patient's vitamin A status, such as malaria, measles, HIV/AIDS, and deficiencies of other micronutrients such as iron and zinc.

Orange-fleshed sweet potatoes have been scientifically determined to be a feasible tool for alleviating vitamin A deficiency. In Kenya the bulk of sweet potato cultivation is carried out in the western part of the country, and western Kenya also has the highest poverty and vitamin A deficiency prevalence. The region was therefore selected for the first orange-fleshed sweet potato (OFSP) pilot project.

Success will have been achieved when Kenya can offer nationwide use of OFSPs as a vitamin A deficiency intervention. Options for achieving this objective may include:

- increasing investments in agricultural research and decentralizing the production of new sweet potato varieties;
- educating farmers on optimal cultivation practices for OFSPs;
- providing incentives for farmers to adopt OFSPs, including a ready market, and removing limitations that lead to producer nonacceptance;
- designing a feasible distribution system that ensures that OFSPs are economically and physically accessible to all households; and
- promoting consumer acceptance by creating awareness of its benefits and developing innovative products.

Your assignment is to recommend a set of policies to the government of Kenya that would facilitate greater production and consumption of biofortified sweet potatoes, taking into account the interests of various stakeholder groups. State the assumptions made in your argument.

Background

More than 40 percent of the world's population suffers from micronutrient malnutrition, including vitamin A, iron, iodine, and zinc deficiencies (Misra et al. 2004). A large proportion of this population is in developing countries. The consequences of malnutrition impose immense economic and societal costs on countries. Micronutrient malnutrition greatly increases mortality and morbidity rates, diminishes children's cognitive abilities and lowers their educational attainment, reduces labor productivity, hinders national development efforts, and reduces the livelihood and quality of life of all those affected (Welch and Graham 2002). Micronutrient malnutrition interventions may be broadly categorized into poverty alleviation strategies, clinical interventions, and nutritional interventions. Nutritional interventions include dietary diversification, fortification, supplementation, nutritional education, and, more recently, biofortification.

Current efforts to combat micronutrient malnutrition in the developing world focus on providing vitamin and mineral supplements for pregnant women and young children and on fortifying foods through post-production processing. In regions with adequate infrastructure and well-established markets for food processing and delivery, food fortification has greatly improved the micronutrient intake of vulnerable populations, particularly the urban poor. In cases of inadequate infrastructure, decentralized processing units, and a high prevalence of poverty, however, fortification programs have not had sustainable impact. In

Kenya it is estimated that 23,500 child deaths annually are directly linked to micronutrient malnutrition and that 70 percent of the children under age six have subclinical vitamin A deficiency (Micronutrient Initiative and UNICEF 2005).

More than 70 percent of the food-insecure population in Africa lives in the rural areas (Heidhues et al. 2004). Ironically, smallholder farmers—the producers of more than 90 percent of the continent's food supply—make up the majority of the rural food-insecure population. The rest of the food-insecure population consists of the landless poor in rural areas (30 percent) and the urban poor. Throughout the developing world, agriculture accounts for around 9 percent of gross domestic product (GDP) and more than half of total employment. In countries like Kenya, where more than 34 percent of the population is undernourished, agriculture represents 30 percent of GDP, and nearly 70 percent of the population relies on agriculture for their livelihood (FAO 2003). Because rural areas are home to more than 70 percent of the poor and the largest proportion of the food insecure, significantly and sustainably reducing food insecurity will require transforming the living conditions in these areas. It is possible, however, to improve the health status of this population through biofortification while at the same time working on long-term poverty alleviation strategies.

Vitamin A Deficiency

Vitamin A deficiency is a serious worldwide nutritional problem that particularly affects preschool-age children. It has been estimated to cause about 70 percent of cases of child blindness worldwide (Underwood and Arthur 1996). Worldwide, 140 million children under five years of age, of whom about 70 percent live in South Asia and Sub-Saharan Africa, have low serum retinol concentrations (< 0.7 μmol/L). East and Southern African countries have the highest prevalence (37 percent) of preschool children with low serum retinol concentrations (Mason et al. 2001). The vitamin and its metabolites are essential for vision, reproduction, and immune function. They play important roles in cellular differentiation, proliferation, and signaling. Vitamin A deficiency in Kenya is most prevalent in children between the ages of 23 months and 6 years (Ngare et al. 2000) and in western Kenya. Vitamin A deficiency not only contributes to preventable blindness, but also leads to increased morbidity and risk of mortality.

Vitamin A deficiency is mainly caused by an inadequate dietary intake of the micronutrient. Rapid growth and frequent infections are also critical factors (Underwood 2004). Other micronutrients also affect vitamin A deficiency. The initial signs of vitamin A deficiency are night blindness and impaired epidermal integrity manifested by hyperkeratosis. If left untreated, night blindness is followed by xerophthalmia, a disease associated with structural changes in the cornea. Epidemiological studies show that consumption of vitamin A and carotenoids is inversely correlated with development of several types of cancer. Vitamin A deficiency during gestation has been shown to induce fetal malformations in animals and is likely to have similar outcomes in humans.

Vitamin A deficiency interventions include dietary diversification, food fortification, supplementation, nutrition education, food production, and, more recently, biofortification. The dietary sources of vitamin A are preformed vitamin A and provitamin A carotenoids. Preformed vitamin A is found in foods of animal origin, whereas provitamin A carotenoids are found in yellow- and orange-fleshed fruits and vegetables and in dark-green leafy vegetables. Palm oil is the universal source of provitamin A for the pharmaceutical industry.

Vitamin A Deficiency Alleviation Projects in Kenya

Current vitamin A deficiency interventions include fortification and supplementation. Although these interventions have had significant impact in projects where they are administered, the results have not been sustainable in the long run, especially in resource-poor communities. This is because resource-poor households consume an insignificant amount of processed foods, limiting the use of fortification. In addition, they tend to be situated in remote areas characterized by poor infrastructure, inadequate health care, and insufficient public funds. This situation limits the use of supplementation as a sustainable intervention. Dietary diversification is still the best way to alleviate malnutrition. It aims at ensuring that the available diet is adequate in every nutrient. Dietary diversification is a long-term objective, but it provides some indicators about what strategies may be sustainable.

NGOs, governments, and companies continue to make concerted efforts to control vitamin A deficiency, especially in resource-poor households that have only limited access to a variety of vitamin A–rich sources. Although a variety of dietary interventions continue to be implemented, this case study will concentrate on three examples of different approaches to the problem.

Dried traditional green vegetables. Most vitamin A consumed in Kenya is obtained in the provitamin A form from traditional green leafy vegetables (Oiye and Shiund 2005). More than 70 percent of Kenya's agriculture is rainfed, however, so these green vegetables are available and affordable to resource-poor households only seasonally. The problem is amplified by the fact that 70 percent of Kenya's land is classified as arid and semi-arid (ASAL). One solution to the problem is to dry the vegetables for storage and consumption during seasons when they are not available in the marketplace. Various organizations have been involved in this approach, including the International Plant Genetic Resources Institute (IPGRI), the National Museums of Kenya, and the Appropriate Rural Development Agriculture Program (ARDAP) in Busia, a district in western Kenya. ARDAP produces vegetables, processes them, packages them, and test-markets the dried traditional green vegetables. Their most famous innovation is "instant *mboga*" (*mboga* is the Swahili word for vegetable), which consists of dried vegetables packed with dried groundnuts, onions, tomatoes, and *sim sim* sauce. The aim of this project is to not only to prolong green vegetable availability by increasing its shelf life, but also to add value and convenience to the products to secure some market share in urban areas. In so doing, ARDAP hopes to help alleviate vitamin A deficiency and poverty in rural areas by stimulating farmers to grow more green vegetables and consequently helping them make money to buy other food crops.

In addition, the organizations involved in this effort create awareness of the benefits of consuming what they refer to as African green leafy vegetables (ALV). They broadcast television shows on how to prepare tasty home-cooked meals, and there is even a cookbook in press. There have been awareness walks, lectures, and entertainment, including traditional dances and plays with the same message. As a result, cottage industries based on dried green vegetable technology are mushrooming around the country.

Vitamin A from mangoes. Vitamin A from Mangoes (VitAngo) is a partnership between nongovernmental organizations and a network of primary and secondary schools. Partners in this project are the World Agroforestry Centre, the Lake Victoria Schools Agroforestry and Environmental Education Network, the Kenya Organization of Environmental Education, and the Kenya Youth Education and Community Development Program. The objective is to reduce vitamin A deficiency and generate income by promoting preservation, use, and marketing of mangoes in an environmentally friendly and sustainable way. The partnership chose mangoes because they have the highest provitamin A content of all the tropical fruits.

The problem is that mangoes are harvested only once a year and at about the same time countrywide. The fruit is highly perishable, and hence farmers are forced to sell their produce at the market price. In most cases farmers make no profits from their sale. More than 50 percent of the mango harvest is lost through postharvest spoilage of the fruit. The VitAngo partnership seeks to address these challenges by preserving mangoes through solar drying and storage techniques. In addition, they seek to promote the expansion of existing earlier- and later-ripening mango varieties. The partnership will produce dried mango snacks like those readily available in the Philippines. Production of other mango products, such as mango juice and mango concentrate, is a technological option not addressed by this organization. The results of this project have yet to be realized.

There is a high demand for good-quality mango varieties with high product yield, juice, and flesh, such as *ngowe* and apple mango. Cooperative-run farms and large-scale farmers with export and factory connections typically deal in these high-end mangoes, which are available in select markets year-round. The mangoes are relatively expensive and beyond reach for resource-poor households. On the other hand, the smaller, hardy, stringy mangoes that require less input are typically grown on smallholder farms for fruits and aesthetic value. These varieties have a low product yield and are available seasonally in the local markets. If the VitAngo partnership is to succeed, it will need to find interventions that ensure that their end products, especially new varieties that they develop, are physically and economically accessible to their target group, resource-poor households.

Orange-fleshed sweet potato projects. Many interventions start out with the intention of reaching resource-poor rural households but end up benefiting middle- and high-income households. To avoid this outcome, HarvestPlus and its partners propose the biofortification of existing staple crops. In Kenya this approach takes the form of orange-fleshed sweet potato projects that use biofortification as a tool to alleviate vitamin A deficiency in the targeted population. The primary target population consists of resource-poor, smallholder farm households. The secondary target population consists of landless, resource-poor households in rural areas and the urban poor. OFSP projects also hope to increase the dietary diversity of tertiary populations by adding to available dietary options. Because vitamin A deficiency is linked with poverty, the tertiary population provides a potential market.

Biofortification is the process of producing food crops that are rich in bioavailable micronutrients (Graham et al. 2001; Bouis 2003). It may involve adding a nutrient that does not originally exist in the crop (as is the case with "golden rice"), increasing the content of an existing nutrient (such as iron and zinc in maize), or making an existing nutrient more bioavailable (bioavailability is defined as the amount of a nutrient in a food that is absorbable from a typical diet and utilizable within the body to perform metabolic functions). Developing orange-fleshed sweet potato varieties can incorporate one or all of these strategies, depending on the variety. Research has demonstrated that micronutrient enrichment traits are available within the genomes of major staple crops that could allow for substantial increases in iron, zinc, and provitamin A carotenoids without reducing yield (Welch and Graham 2002). In fact, OFSPs have been scientifically determined to be a feasible tool in alleviating vitamin A deficiency due to inadequate intake (van Jaarsveld et al. 2005). Apart from being a precursor of vitamin A, beta-carotene (of which OFSPs are an excellent source) is said to increase the bioavailability of iron from the diet (Garcia-Casal et al. 2000).

Biofortification has many advantages as a nutritional intervention:

1. It does not require a change in behavior by farmers or consumers where the crops are already widely produced and consumed by poor households in the developing world. The introduction of the orange-fleshed sweet potato in regions where the white-fleshed sweet potato is traditionally consumed, however, may pose a challenge or an opportunity, depending on the perceptions of the target population.
2. Biofortification capitalizes on the regular dietary intake of a consistent and large amount of food staples by all family members, ensuring an increase in nutritional status of the household
3. The multiplier aspect of biofortification across time and distance makes it cost-effective. After the initial investment to develop seeds that produce plants that fortify themselves, recurrent costs are low and germplasm can be shared internationally. In addition, since propagation of sweet potatoes is through vines, farmers can (and do) informally disperse the varieties to neighbors and friends.
4. Biofortification provides a feasible means of reaching undernourished populations in relatively remote rural areas. It delivers naturally fortified foods to people with limited access to commercially marketed fortified foods. It is this aspect of biofortification that makes it a suitable intervention for Kenya.

As with any model, assumptions made must hold true to achieve success. The following assumptions are made with regard to biofortification:

1. The target population already consumes a non-biofortified variety of the crop to be introduced.
2. The vulnerable target group has both economic and physical access to the biofortified crop.
3. The target group will continue to consume the staple in sufficient quantities after biofortification.

4. Preparation of the biofortified crop as food will not reduce the amount or bioavailability of the micronutrient in the food.
5. The added or increased micronutrient will have synergistic rather than negative interactions with other micronutrients already in the food matrix.
6. Biofortification will not worsen the flavor of the food crop.
7. The farm yield of the biofortified crop will be equal to or better than that of the non-biofortified crop being replaced.
8. The tools used for biofortification, such as classical plant breeding and genetic engineering, are legally acceptable in the countries where the target population lives.
9. It is economically feasible for farmers and markets to deal in biofortified crops.

In Kenya the white-fleshed sweet potato is consumed mainly in western Kenya but is available in many markets countrywide. The production of the OFSP on farm households ensures physical and economic access. Sweet potatoes are consumed boiled whole, mashed with legumes, or eaten with leafy vegetables, meat, or fish. The crop is widely consumed in rural areas. Because sweet potatoes are a woman's crop, household access to the OFSP is assumed. When women control both production and consumption of a particular crop, an increase in household nutritional status is likely to be achieved, because women tend to keep most of the crop for home consumption, whereas men tend to sell most of the crop (Sachs 1996). Even when women sell some of the crop, sales tend to be small and income earned remains under the control of the female producers, who channel it back to the household (Quisumbing et al. 1998). There is no evidence of negative nutrient bioavailability interactions. Studies show that after processing, OFSPs still contain most of the nutrient.

To be selected as a potential fortification vehicle, a food should be commonly consumed by the target group, affordable, and available all year round. Sweet potatoes are consumed as a secondary staple in Kenya (Hagenimana et al. 1999). Traditionally, white-fleshed sweet potatoes are produced mainly in western Kenya, the region with the highest prevalence of vitamin A deficiency. Western Kenya was thus selected as the first test site for OFSP.

Initial OFSP projects faced many challenges. First, there was the need to develop varieties that would adapt to Kenya's climatic conditions and yet be resistant to sweet potato virus diseases. Conventional breeding techniques were used, and these challenges have been overcome. The next step was to identify farmers who were financially able to grow OFSP, had available extra land, and were willing to grow the crop. In some places the project took the form of establishing demonstration plots in schools or community development centers. Project implementation has gone a step further by creating awareness through education and new product development. These products include cakes, breads, and homemade pastry products such as *chapatti* and *mandazi* that have OFSPs in their composite flour, OFSP flour in a child supplement, and home-cooked meals containing OFSP. There is currently an OFSP flour in the supermarkets.

Policy Issues

The policy issues facing biofortification in Kenya may be classified into implementation issues, structural issues, and exogenous issues. The issues discussed herein refer to the biofortification of not only the sweet potato, but also any other crop in the future. The issues limiting Kenyan agricultural growth nationally affect sweet potato biofortification and are bound to affect any other crop introduced into the country.

Implementation Issues

OFSP projects in Kenya face four main challenges:

1. Poor infrastructure, especially in the resource-poor regions of the country, makes these regions inaccessible.
2. Maize is the main staple food crop in the country and hence a strong competitor for land and resources, particularly in resource-poor households.
3. Kenyans prefer white-fleshed sweet potatoes, resulting in high risk to farmers and traders who deal with the OFSP.
4. Education, training, and marketing on the use of OFSP as a vitamin A deficiency intervention requires large investments of money, time, human resources, and technology.

Some of the issues to consider are: How sustainable is the project? Is there an incentive for farmers to grow biofortified foods? Who should control or lead the biofortification initiative? Can Kenyans produce higher crop yields and more nutritious foods from thinning soils, making food more affordable and accessible to increasing numbers of people? In addition, rainfed agriculture predominates in Kenya, where only 25 percent of land area is arable. Stakeholders may need to (1) justify the addition of OFSPs on land where sweet potatoes are not currently grown and would be competing with other crops, and (2) contribute toward irrigation projects so that OFSPs can be grown on land that is currently not arable in places where some of the poor population lives.

Stakeholders also need to ensure that OFSPs are not only available, but also accessible to poor nonfarming households. Interventions usually tend to benefit middle- and high-income households. This situation in turn creates barriers for resource-poor households. Access to the OFSP is complicated not only by poverty, but also by lack of roads and infrastructure to move food swiftly from place to place. Kenya also suffers from underinvestment in agriculture and agricultural research and development. Because there is no dominant farming system on which food security largely depends, various approaches need to be created for the different farming systems. For example, where mixed farming is practiced, animal manure may be used on sweet potatoes and sweet potato vines may be fed to the animals. Where only maize and beans are grown, an incentive to introduce the crop is needed. Stakeholders must identify what farming system or systems they want to pursue. Lastly, stakeholders will need to seek solutions to the problem of postharvest losses since OFSP are highly perishable goods.

Structural Issues

The majority of sweet potato farmers are smallholders who have problems gaining access to the limited market available. These farmers face barriers to market penetration caused by poor infrastructure that increases their transportation costs, a limited resource base, lack of information, lack of or inadequate support institutions, poor policies, requirements for large initial capital investments, and limited product differentiation. Whereas almost any of the farm produce sells at a village-level market, consumers in rural areas are quick to discriminate against produce that is comparatively inferior, hence farmers have, over time, adapted to selling only their better produce. This highly subjective process has worked traditionally. When the same farmer wants to sell produce to the urban market, however, subjective standards no longer work. The farmer is forced to meet relatively objective standards such as size, quantity, and quality.

Exogenous Issues

Stakeholders may need to address and help alleviate exogenous issues that are not in their jurisdiction but have a direct impact on their efforts. Disease and infection continue to plague the country. Diseases such as malaria, tuberculosis, and HIV/AIDS reduce the person-hours available to agriculture and household food acquisition. This situation is particularly serious for resource-poor rural households that depend on the labor of every member of the family for their livelihood. Also, it is mainly the poor who do not have physical or economic access to health care. In Sub-Saharan Africa AIDS is the leading cause of adult mortality and morbidity. The Food and Agriculture Organization of the United Nations (FAO) estimates that by 2020 the epidemic will claim the lives of 20 percent or more of the population working in agriculture in many Southern African countries. More than two-thirds of the total population of the 25 most-affected countries resides in rural areas, affecting agricultural production as well as farm and domestic labor supplies. Lack of resources also makes it more difficult for HIV-affected households to supplement their diet by purchasing more nutritious and varied foods. The effect of malnutrition on food security is further exacerbated by the fact that individuals affected by disease and infection have greater nutritional requirements.

Stakeholders

Stakeholders in vitamin A biofortification in Kenya include those who are interested in biofortification in general, those who promote OFSP projects, and those who promote alternative interventions.

Women's Groups

Women's groups are common throughout Kenya. Because sweet potatoes are a woman's crop, women's groups in rural areas are a useful entry point for testing new varieties in on-farm trials. Women's groups are widely recognized as the grassroots units through which change can be initiated and implemented, particularly with regard to family food production and nutrition. Although each group is formed to achieve specific objectives, they all have an underlying objective of alleviating poverty through profit-generating projects, improving health and nutrition in their households, and improving education. For this reason, women's groups are open to an intervention that would improve the health of their households. The key in maintaining their interest lies in meeting more than one of their objectives. In the past the most successful projects have been those that combine nutritional benefits with income-generating projects. Evidence suggests that it would serve OFSP projects well to involve women's groups, in both the rural and urban areas, in new product development and sale of products. Formal procedures need to be established, however, to facilitate financing, quality assurance, and marketing.

Farmers

About 80 percent of all Africans depend on agriculture for their livelihoods. The agricultural sector also accounts for 70 percent of full-time employment, one-third of total GDP, and 40 percent of total export earnings (InterAcademy Council 2004). Hence it constitutes the most important source of income and employment for the majority of households in Sub-Saharan Africa. Alleviating vitamin A deficiency in Kenya will require

- more investments in the agricultural sector to encourage the use of inputs;
- an increase in agricultural productivity; and
- more efficient and better-functioning agricultural markets for both producers and consumers.

In the marketplace, the value of root crop production is about 14.9 percent of the value of maize production, 28.9 percent of the value of bean production, and 8.6 percent of the value of all food crop production (Alumira and Obara 1998). Hence there is a need for a financial incentive if farmers are to engage in active root crop production. For example, the private sector has not provided input credit to farmers owing to its inability to enforce loan repayment and the high transaction costs of lending to dispersed, small-scale farmers. One solution may be to introduce export crop production schemes for sweet potatoes. Studies have shown that such schemes tend to encourage farmers to invest in modern inputs, primarily because these schemes are both profitable and stable and often vertically coordinated in both input and output markets. If demand for sweet potatoes can be increased in areas of the country that do not grow sweet potatoes, then farmers in Western Kenya and other sweet potato–growing regions could grow the OFSP, ensuring a sustainable supply.

Demand for sweet potatoes in Kenya has, however, decreased. The main reason given for this decline is that people have become more modernized and prefer modern exotic foods to traditionally consumed foods. Sweet potato is an inferior good; demand for it decreases when the consumer's income rises. A different school of thought, however, proposes that the decrease in consumption is due to reduced supply. Some of the reasons leading to a reduction in sweet potato supply are tied to agricultural conditions and may provide opportunities for farmers. The reasons given for reduced supply are:

1. Farmers are planting fewer sweet potatoes than they did five years ago for many reasons, including competition from maize, wheat, and other crops.
2. Kenya's erratic and unreliable rainfall pattern has led to decreasing and unreliable sweet potato harvests, but more drought-tolerant varieties are now available.
3. Poor crop husbandry practices, especially in pest control, have led to lower production.
4. Increasing population size has resulted in increased land fragmentation and decreased landholding sizes. This fragmentation makes it difficult to cultivate more sweet potatoes since priority is given to the main staple, maize.
5. Not all areas of the country produce the crop, and sweet potatoes are expensive in areas where they are not grown.

Finally, most of the farmers have very small plots, about 0.5 hectare on average. They therefore incur high risks in taking up new varieties, especially in view of uncertain markets.

Nongovernmental Organizations

The pioneer in the use of the OFSP in interventions to combat vitamin A deficiency is the International Potato Center (CIP), in collaboration with Vitamin A for Africa (VITAA). Their effort to develop and distribute OFSP varieties is partially funded by HarvestPlus, a program of the Consultative Group on International Agricultural Research (CGIAR) that seeks to alleviate micronutrient malnutrition through plant breeding by developing staple food crops that are rich in micronutrients. HarvestPlus works through a global alliance of research institutions and implementing agencies in developed and developing countries. The organization currently focuses on three micronutrients: iron, vitamin A, and zinc. It is currently pursuing the first phase of research on beans, cassava, maize, rice, sweet potatoes, and wheat.

CIP, in collaboration with the Kenya Agricultural Research Institute (KARI), continues to develop OFSPs that are drought-tolerant, are resistant to viral infection, and have higher dry matter for increased consumer acceptability. VITAA is in charge of nutritional education and product development to ensure sustainability. The nutritional education highlights the importance of vitamin A in diets, especially for children.

The Kenyan Government

The Kenyan government has been supportive of the biofortification program and permitted the use of genetically modified crops in the country. It even encourages research in this area. There is still a need for more work, however, if the OFSP project is to be a national success. The consumption of sweet potatoes has decreased since 2001 mainly owing to low production levels, increased poverty, and a change in eating habits due to rural-urban migration. In addition, agricultural markets have been crippled owing to poor infrastructure (roads, irrigation, communication networks, and marketing services), limited access to rural credit, limited upscaling of the implementation of research findings owing to an overstretched agricultural extension department, limited public expenditures on agriculture, inadequate human capital development, and poor weather and soil quality.

Kenya Agricultural Research Institute

KARI provides planting materials and agricultural extension agents and trains women in methods of growing and harvesting sweet potatoes, postharvest processing, and preparation techniques. They also hold health and nutrition education sessions to heighten awareness of the contribution vitamin A makes to children's health and development and to encourage consumption of food products using new sweet potato varieties. These are vital functions that need to be implemented and monitored continuously. If OFSP farming spreads nationwide, the Ministry of Agriculture will need to take up these functions.

Policy Options

In view of the issues facing agriculture in Kenya, distributing beta carotene–rich varieties of sweet potatoes and providing minimal agricultural support for production are not sufficient to ensure the sustainability of the projects. A number of issues need to be addressed.

Implementation Policies

Kenya has many alternatives as far as the provision of dietary vitamin A–rich sources is concerned. It may choose to nationalize the western Kenya OFSP project. One approach would be to introduce OFSPs on all government-run school plots. The government could mandate this step for all schools through the Ministry of Education, and the plots could serve as demonstration centers for neighboring communities. Kenya used this model between 1980 and the late 1990s as a means of improving national agriculture.

The biofortification interventions need to be sustainable within the context of vulnerable communities. Therefore, biofortified food crop projects should include applied biotechnology to enhance yields in view of depleted soils and minimal inputs. Scientific progress and political commitment are key factors in ensuring success, but consumer and public acceptance is key for sustainable progress. Achieving public confidence will require increased partnerships among scientists, policymakers, community leaders, and consumers in the decision-making processes. Adoption of biofortified crops with visible traits will require that both producers and consumers actively accept the sensory changes in the crops, in addition to benefiting from equivalent productivity and end-use features. Ensuring this acceptance will demand consumer education and nonconventional product development that enhances the advantages of the visible trait. For those traits that are not visible, both the consumer and producer will need added incentives to make the necessary switch to "enriched" food crops. Hence, crop productivity and improved end-use features such as flour quality are very important.

Kenya also has the option of promoting OFSP as a region-targeted intervention in western Kenya. Western Kenya is the region with the highest vitamin A deficiency and poverty prevalence. It also is the region where the bulk of sweet potato production and consumption occurs. Although this option makes economic sense, it is not ethical unless other suitable interventions are designed for the rest of the country, for evidence shows that the prevalence of vitamin A deficiency in rural areas in the rest of the country is not significantly different. Hence, Kenya needs an intervention or set of interventions to ensure alleviation of vitamin A deficiency nationwide.

A second approach is to promote the use of other vitamin A–rich crops, such as pumpkins, green leafy vegetables, papayas, carrots, and mangoes, that are already grown and consumed in the country. This approach would strengthen the efforts of groups that promote traditional green leafy vegetables. A third option for Kenya may be to introduce and promote the use of palm oil, as has been done in West Africa. The oil could be obtained from the coastal region.

The first two options do not require drastic changes in the dietary habits of the population. In fact, promotion of more than one source of vitamin A is bound to be more sustainable. On the other hand, the promotion of palm oil has industrial implications. The palm oil industry would introduce employment opportunities and consequently help alleviate poverty, but the unit price of the oil may be too high for poor and vulnerable households.

Whichever option is chosen, there is a need for health and nutrition education to promote consumption by at-risk populations, including young children. Training on meeting health standards and good manufacturing practices is also necessary for those who take up food processing. Extension workers would need to be hired for biofortification promotion alone. This group should be trained in nutrition and be supervised for quality-control purposes. In addition, agricultural policies should subsidize sweet potato production to reduce the risk taken by vulnerable farmers.

Land tenure needs to be addressed. Many poor households do not own the land on which they live and are therefore not inclined to use inputs. In addition, women have little control of the land except on the small pieces allocated to them by their husbands at the time of marriage. This situation limits the land available for sweet potato cultivation. If the men's portion of the land is to be made available for OFSP or other vitamin A–rich foods, there needs to be a well-functioning, ready market for these crops. One way to help create such a market is to develop cottage industry opportunities or involve the food industry through product development. OFSP flour is already available in the market, but there is still room for expansion. Other products could include composite weaning foods for consumption in urban areas, and sweet potato substitution in baked goods, *mandazis*, *chapattis*, bread, and buns on a large scale.

Structural Policies

The Kenyan government needs to eradicate the factors that inhibit agricultural expansion in the country. There is a need for improved infrastructure, including roads and transportation, electricity and communication networks, storage and market facilities, research and extension programs, and market information systems. Nutritional education should be provided through radio and local television programs and at agricultural shows, which seem to set trends in the towns where they are held. Access to capital continues to be a limitation for the poor who do not have available assets. Providing incentives for microfinancing institutions in the country would alleviate this problem.

Exogenous Policies

Measures need to be taken to ensure that vitamin A deficiency alleviation measures continue to be physically and economically accessible to the poor households for whom they were designed.

Assignment

Your assignment is to recommend a set of policies to the government of Kenya that would facilitate greater production and consumption of biofortified sweet potatoes, taking into account the interests of the various stakeholder groups. State the assumptions made in your argument.

Additional Readings

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